

Conducting Cardiopulmonary Evaluations of County of Los Angeles Safety Personnel

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FEW local or State governments have comprehensive occupational health services for their employees. Although workmen's compensation insurance legislation was passed by Congress in 1908 for Federal employees, occupational health programs were developed primarily within private industry as an effort to decrease compensation costs.

Government is a large employer. In 1969, there were 12,691,000 persons working for Federal, State, or local governments, exclusive of those in the military services. This number represents about two-thirds the size of the labor force in manufacturing, 19,587,000 in 1968 (1). Yet in a survey conducted a decade ago, only nine States reported the existence of employee health services, and among the 100 cities queried, the pattern of such services was spotty (2).

Los Angeles County is among the units of government that have, in the interval since the survey, instituted an occupational health service,

The county employs 78,000 persons in nearly 70 departments and special districts that are spread over 4,000 square miles.

Background

For years, adding new personnel to the county payroll was a cumbersome process because of delays in verifying an applicant's medical qualifications. Standards used in the physical evaluation were rigid; they excluded many candidates capable of filling jobs on the basis of their experience and training because the applicants had anatomical variations from the physical standards. Furthermore, exhaustive searches were often necessary to obtain a candidate's medical history among many past sources of care. Delays in putting applicants into jobs became intolerable.

The county's director of personnel, heading a newly organized department, wanted to remove this bottleneck. After a study of many months, the Board of Supervisors of the County of Los Angeles authorized the creation of an occupational health service (OHS), which became operative October 1, 1968, when 68,000 persons were employed.

The occupational health service has expanded its capabilities since 1968 and now offers applicants preplacement examinations; to employees it offers a full preventive medical program, periodic health appraisals, a health program for execu-



*Measuring skinfold thickness over triceps area
Photo by Norman Wexler*

tives, psychological counseling in several areas, general and special nursing services, environmental health expertise, immunizations, health education, and emergency medical care, as well as consultation to management on deficits in employee performance.

The occupational health service has a staff of 109 persons. The five full-time physicians are all diplomates of the American Board of Preventive Medicine. There are, in addition, 20 part-time physicians who serve either as consultants or examining physicians; several are board certified in other specialties, such as allergy, dermatology, and orthopedic surgery. On the nursing staff are

13 nurses, 10 of whom are classified at one level or another of occupational health nurse. A staff of four environmentalists, two at the DrPH level, cares for the industrial hygiene of the worksite, and three professional members comprise the epidemiology section. Remaining members of the staff are in the usual clerical and secretarial classifications or are occupational health technicians, radiology technicians, and licensed vocational nurses. The cardiopulmonary laboratory is unique in that, under physician direction, it has a staff of five exercise physiologists and two attendants. Other staff positions include health educators, administrators, medical records personnel, and a large group devoted to counseling, primarily counseling psychologists and clinical psychologists.

The primary facility of the occupational health service is located in the Civic Center of Los Angeles, while the medical examination facility is situated about five blocks away. A mobile field team serves fire stations where field screening of employees preparatory to approval for participation in exercise programs is carried out.

Cardiopulmonary evaluations of current employees and applicants are an unusual feature of the County of Los Angeles' occupational health service. They are conducted in the cardiopulmonary laboratory created for this portion of the health appraisal of employees.

Matrix of Employees

A high percentage of persons employed in the public sector work in so-called safety assignments such as law enforcement, suppression of fires, services in the courts (marshals and bailiffs), life-guarding at beaches, and in investigations conducted by the district attorney's office. Except for lifeguards, persons engaged in these activities are covered by a State law in which it is stated that when heart disease develops in such a worker, the condition is presumed to be job related, and full medical care, compensation, and sick leave are provided by the employer. In 1972, a bill was introduced into the State legislature which, had it been passed, would have changed the retirement laws for all safety personnel so that the presumptive clause would have become a conclusive clause, as it related to cardiac disorders. It is anticipated that the bill will be introduced again this year.

The concerns about heart disease involve not only the primary, undesirable result of acute and

chronic illness but the more disquieting role of discontinuity among firemen who must be retired and among other workers who face reassignment to less stressful tasks. Also, there are the great costs to the employer—about \$45,000 in workmen's compensation costs per safety employee with heart disease—and the loss of valued, productive personnel. If a service-connected disability retirement is granted, for example, to a 44-year-old worker with a 42-year-old spouse, the total benefits paid would reach nearly \$108,000 over the remaining expected longevity, or about \$600 per month.

It was logical, therefore, for the OHS to institute a physical fitness program to combat the forces leading to one significant form of heart disease, atherosclerotic coronary disease. Other cardiac disorders are unimportant to the service, because an applicant for a safety position would not be hired if he showed evidence of pathologic anatomic change or dysfunction. The job requirements are physically and emotionally demanding.

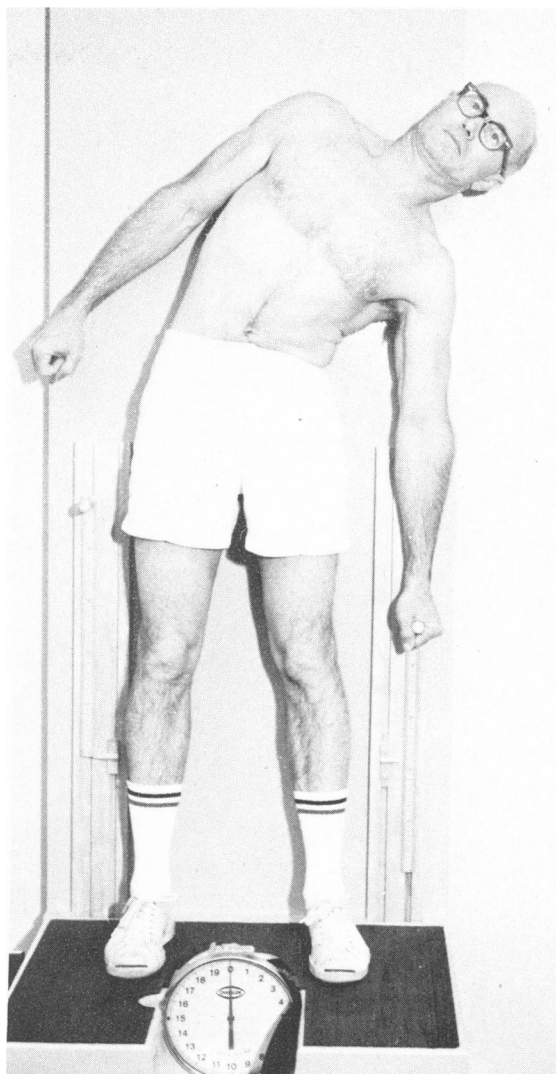
To initiate a program of prevention it was necessary first to identify the employees at risk, to examine all applicants for safety positions so that counseling could be offered persons who were likely candidates for coronary heart disease, and to reappraise periodically those workers who had undergone an initial cardiopulmonary study.

The Examination, Phase 1

The target population was all safety personnel in the five departments of the sheriff, the forester and fire warden, the marshal, the district attorney, and beaches. Included additionally as a group at risk was a limited number of top executives.

The examination process has two phases; the first consists of the following elements:

- Completion of a medical history
- Snellen test of visual acuity
- Measurement of field of vision
- Color vision test with pseudoisochromatic plates
- Audiometry based on the ISO standard
- Measurement of height and weight
- X-rays of chest and abdomen, the latter to detect aortic atherosclerosis
- Resting 12-lead electrocardiogram, interpreted later by a cardiologist
- Urinalysis
- Hematologic survey
- Blood chemistry: serum albumin, serum triglycerides, serum cholesterol, serum creatinine, glucose, alkaline phosphatase, total protein, serum globulin, albumin-globulin ratio, thyroxine (total by column), serum glutamic pyruvic transaminase, and uric acid



Measuring extent of lateral mobility of spine on specially designed equipment

Photo by Norman Wexler

Sickle cell trait test for all black personnel, and subsequent disease tests when indicated

Results of all evaluations are assembled and reviewed, and a medical conclusion is formulated as to the person's health status. If the electrocardiographic findings are within normal limits, the examinee will be exercise tested. If there is evidence of hypertension, the person is referred to his physician for treatment for 3 months. A decision regarding additional testing is made at the end of that period. When the electrocardiogram indicates an old myocardial infarction, the exercise testing will be undertaken, but with great caution. If the electrocardiogram taken with the person in a resting position shows evidence of

ischemic heart disease, he will not be subjected to the physiological stress of exercise testing.

The Examination, Phase 2

When the safety employee comes to the cardiopulmonary laboratory for phase 2 of the examination, the 12-lead resting electrocardiogram is repeated and, if there is again no evidence of ischemia, the exercise evaluation is carried out. Unusual observations at this point are rare, but if there is some abnormality, the protocol is cancelled or testing is delayed until the consulting cardiologist concurs in the cancellation or advises testing with his being present as a monitor.

Exercise testing is not limited to electrocardiography under work loading. Height and weight are determined again and the percentage of body fat is calculated, using Lange skinfold calipers, to obtain measurements at five areas. Spinal mobility is determined by quantifying the range of lateral and forward trunk flexion, trunk rotation, and trunk extension; these procedures are carried out on mensuration devices specially developed by laboratory personnel. Grip strength is measured bilaterally, using a handgrip dynamometer, and the side of dominance is noted. The strength of the hip extensor muscles of the back is checked, and measurements are made of the strength of thigh musculature, using a laboratory-designed leg and hip dynamometer.

Before and after exercise, the blood pressure levels are recorded with the subject recumbent, on quick-standing, and after standing 1 minute. The Hyman index formula (3) is used to determine the state of the vascular system. Pulmonary function is tested with the Collins' Stead-Wells spirometer to measure the forced vital capacity and the maximum breathing capacity. The heart and lungs are examined before ergometry.

Most significant in the protocol, though, is the determination of cardiovascular tolerance for work at heart rates of 100, 120, 140, and 160 beats per minute, maintaining each incremental change for 5 minutes. To determine tolerance, the subject rides a bicycle ergometer controlled by heart rate. He pedals at a rate of 60 to 70 rpm against resistance automatically applied by the pedal device. The heart rates mentioned are preset and programmed into the equipment so that the test is carried out smoothly unless an event indicates cessation.

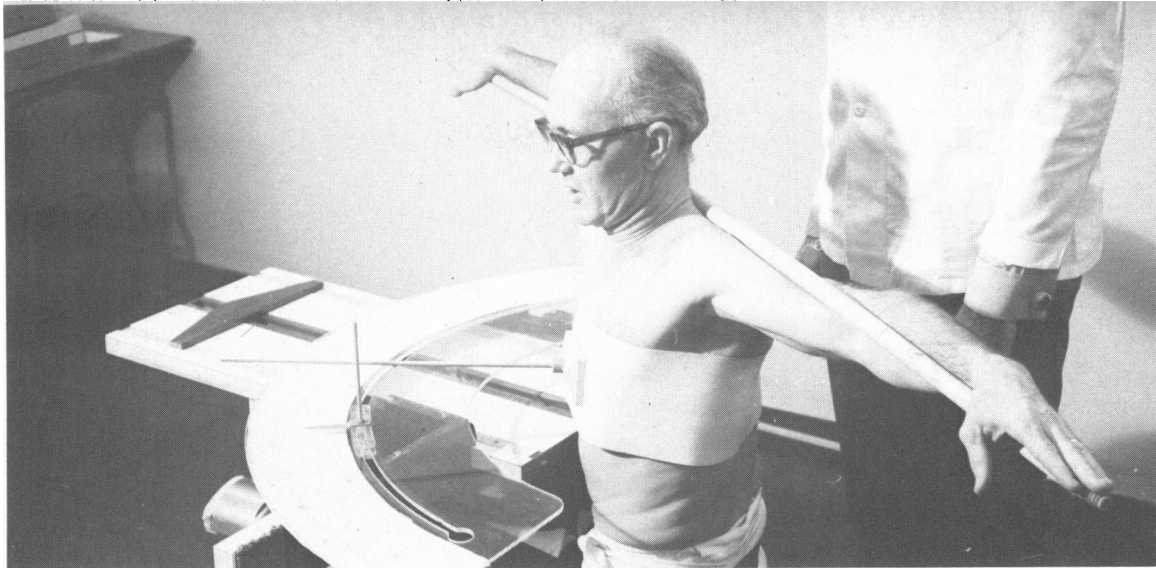
The electrocardiographic pattern is displayed on an oscilloscope for constant monitoring and recorded simultaneously on permanent magnetic tape. A permanent record is obtained from intermittent strip recordings taken at the end of each step of the test or at any time desired. Sphygmomanometric readings are taken during rest and peak workloads, at the conclusion of each test step, and at specific points during the recovery period of 6 minutes. Criteria for the determination of clinical ischemic heart disease follow established standards. Limits for systolic and diastolic blood pressure levels govern the continuing or stopping of the procedure. Oxygen consumption is measured during ergometry.

A heart-health index is obtained from a quantification of scaled values for eight variables—age, heredity, sex, weight, smoking history, exercise program, cholesterol level, and blood pressure. The index was developed by John L. Bower, MD, associate professor of physical education and medical director of the Exercise Physiology Laboratory, California State University, San Diego. The index has not been described in the literature.

An example of the scoring system for one variable, smoking, follows:

Table 1. Subjects exercise-tested in cardiopulmonary laboratory, County of Los Angeles occupational health service

Subject	Employees		Applicants		Total	
	Number	Percent	Number	Percent	Number	Percent
Firefighters.....	529	29	182	10	711	39
Sheriff's personnel.....	181	10	522	29	703	39
Marshal's personnel.....	141	7	64	4	205	11
Lifeguards.....	110	6	.....	.....	110	6
Executives.....	53	3	.....	.....	53	3
Contract city firefighters.....	29	1.7	.....	.....	29	1.7
District attorney's office investigators.....	.....	.....	2	.1	2	.1
Miscellaneous patients.....	3	.2	.....	.....	3	.2
Total.....	1,046	56.9	770	43.1	1,816	100.0



*Determination of degree of rotation of trunk with specially designed equipment
Photo by Norman Wexler*

Variable	Score
No smoking	0
Cigar or pipe	1
10 or fewer cigarettes per day	2
20 or more cigarettes per day	3
30 or more cigarettes per day	5
40 or more cigarettes per day	8

Cholesterol level is scored as follows:

Cholesterol level (mg per 100 ml)	Score
Under 180	1
180-205	2
206-230	3
231-255	4
256-280	5
281-330	7

The total values for each of the eight variables are added, and the resultant scores are classified. Group I, with scores 6-11, represents a very low risk in the development of cardiovascular disease. Group II, scores of 12-17, is classified as low risk, while group III, 18-23, is categorized as an average risk. The next step up, group IV, 24-32, is labeled "high risk," while group V, 33-42, is termed "a dangerous risk." Group VI, 42-60, is interpreted as an extremely dangerous risk.

Caseload

From the inception of the fitness program in November 1970 through March 1972, a period of 17 months, 1,816 exercise protocols have been carried out, primarily on safety personnel (table 1).

Not all subjects were able to complete the tests,

that is, the bicycle ergometer segment of the protocol. The number of partial tests and reasons for noncompletion may be seen in table 2. Of the 1,816 tests begun, all but 10.9 percent were completed. The greatest number failing to finish were persons in poor physical condition and those whose lower extremity musculature was inadequately toned so that they failed to reach the 20-minute limit which, at a heart rate of 160, is but 85 percent of maximal capacity.

Results

To date, the greatest number of positive findings of heart disease have been encountered among firemen, for they represent the largest group examined. In keeping with the premise stated previously of evaluating those at greatest risk,

Table 2. Incomplete exercise tests conducted in cardiopulmonary laboratory, County of Los Angeles occupational health service

Reason for noncompletion	Number	Percent
Leg fatigue.....	82	41.2
Extremely elevated blood pressure.....	54	27.1
Electrocardiographic changes.....	32	16.1
Technical difficulties.....	13	6.6
Rapid increase in heart rate.....	9	4.5
Difficulties from old injuries of lower extremities.....	5	2.5
Elevated resting heart rate and blood pressure.....	3	1.5
Elevated resting heart rate.....	1	.5
Total.....	199	100.0

the firefighters were the group examined initially, the oldest being seen first. At present, firemen in their early 40s are undergoing the two-phase procedure. Fifty-two men were removed from duty because of changes during either resting or dynamic electrocardiography. After subsequent examinations, including vector cardiography or coronary cineangiography, 15 were allowed to return to work. The 37 who were taken off duty began a year of sick leave, and subsequently they were retired. Nearly all of them received a service-connected disability retirement.

Of these 52 firemen, 21 were taken off their jobs for study because of positive findings on resting electrocardiograms, the remainder as a result of the ergometer tests. Of the 31 going to phase 2 exercise testing, 29 were normal, and two were ischemic on repeat 12-lead resting electrocardiograms. (Because of the more recent electrocardiographic evidence of ischemia, it was decided to exercise test these two men under the close monitoring of a cardiologist.) With exercise, six proved to be normal, dysrhythmia was found in three; ischemia was encountered in 19; and three demonstrated both dysrhythmia and ischemia. After exercise, ischemia persisted in 16, and the one with dysrhythmia continued to manifest this irregularity.

Among the other safety employees, coronary heart disease, manifested by abnormal results of one test or another, was found in two deputy marshals, six sheriff's officers, two lifeguards, and 15 executives. Five firefighters and one executive subsequently underwent coronary artery bypass surgery using saphenous vein grafts.

The most frequent finding among applicants was either a high heart-health index, indicative of possible future ischemic heart disease, or poor performance on exercise testing. Although response electrocardiograms were normal, the candidates had a more elevated heart rate when challenged by a workload on the bicycle than did long-service safety workers at the same level of demand.

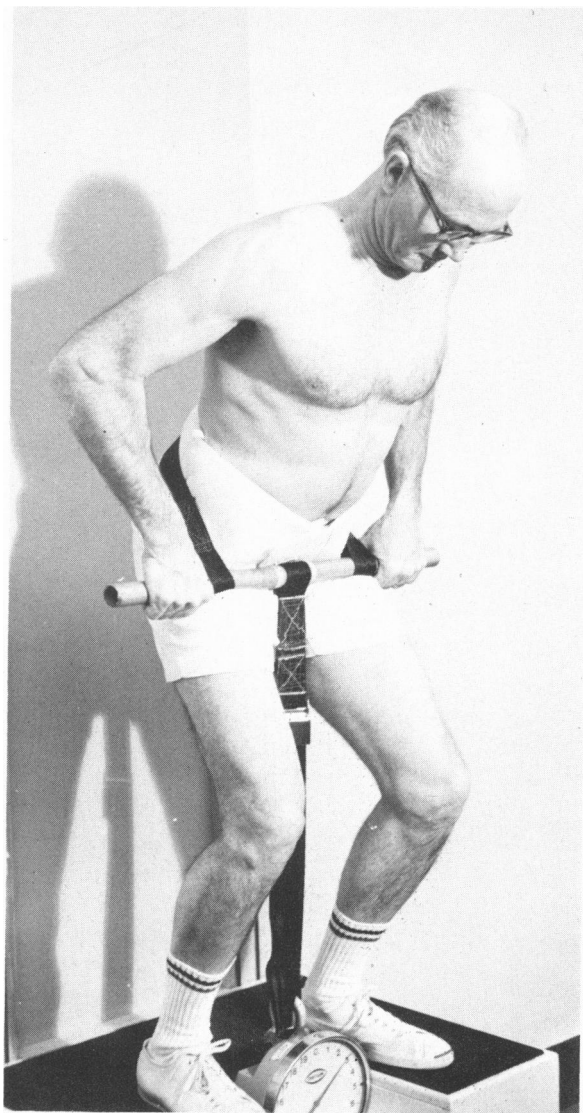
There was evidence of hyperlipidemia in many moderately obese employees and positive fundoscopic findings in five firemen, and five of the group also had radiologically significant calcification of the abdominal aorta.

The psychological and sociological effects on the firemen of cessation of work were extensive and deep and are being reported separately. The

other safety personnel were reassigned to less stressful positions and, apart from experiencing fairly severe changes in their self-image, have continued working without difficulty.

Peer Review

When coronary artery disease was encountered in examinees in the cardiopulmonary laboratory, the person was immediately referred to a cardiologist outside the OHS for study, under the county's self-insured workmen's compensation program. On receipt of all findings, both intramural and external, the results were forwarded to the program's consultant, George C. Griffith, MD, professor emeritus of cardiology, University of



*Test of knee extension strength, using specially designed equipment
Photo by Norman Wexler*

Southern California School of Medicine, for review. In all cases, his judgment was followed as to the medical significance of the findings.

Counseling

All persons going through the fitness test procedures are counseled as to weight reduction, smoking withdrawal, lowering of blood lipids, and individual exercise regimens. Through such alterations of his life style, one fire department executive was able to return to work, reversing the physiological changes observed earlier. A 30-year-old fireman with complete bundle branch block has had to remain off duty. Individual counseling is provided, and printed materials are given to the

examinees to support the oral review. In a few cases individual psychological counseling has been used, but for most firemen, the counseling staff of the OHS has held weekly, then semimonthly group sessions to help the men plan their future, cope with their anger, further their rehabilitation, and create mutual support.

Future Changes

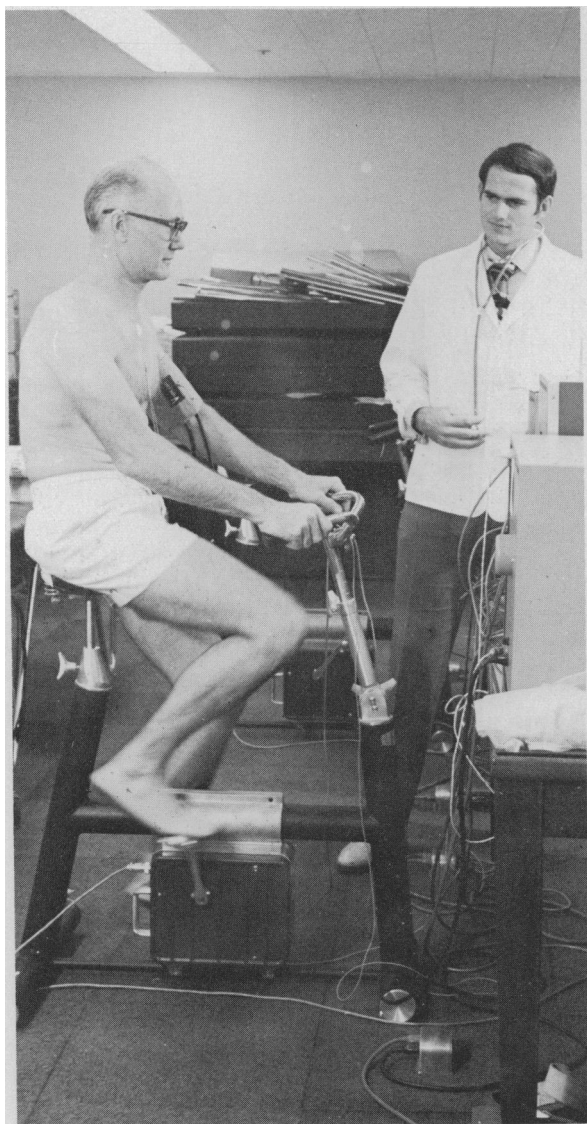
Within the next few months the cardiopulmonary laboratory will automate its ergometric equipment to double its present capacity, 13 phase 2 exercise tests per day. Field teams will examine firefighters preliminarily at their duty stations, and exercise programs will be initiated, along with counseling on nutritional needs, reduction of hypercholesterolemia, and food preparation at the station and at home.

Employees showing evidence of disease during resting electrocardiography will be brought to the OHS for the two-phase examination ahead of their regularly scheduled appointments. With a nutritionist to train both nursing and exercise physiology staff, dietary counseling will be more skillful. Smoking withdrawal groups are planned to aid in efforts to reverse coronary atherosclerosis.

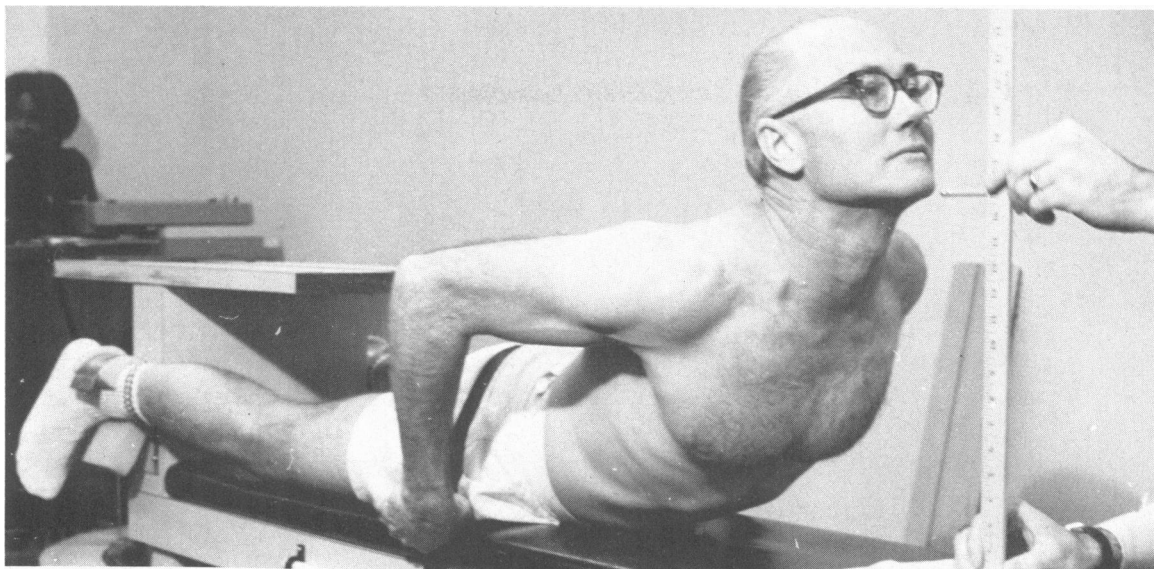
To pinpoint the cause of the presumed high prevalence of atherosclerotic heart disease in firefighters will require intensive research. Social Security Administration data (4) show that, among firemen who are disabled and retire, the proportionate morbidity ratio is nearly twice that of 205 other occupations.

One can only speculate on the possible explanations. Is the life of the firemen a sedentary one, intermittently upset by sudden and extreme demands for maximum expenditure of energy? Are the high food intake and cigarette smoking, normal concomitants of relaxed station life, more productive of intimal deposition than in slightly more active employees? Is there any causal relation between smoke inhalation and a hastening of the coronary occluding process? More intensive comparative studies remain to be done.

This report covers only one aspect of the occupational health of public safety workers. There are other potential hazards for law enforcement officers, and for firemen, of course, there are the actual physical hazards in fire suppression. Hazardous for court bailiffs is their sedentary work; schemes to increase their physical activity might be devised. Law enforcement officers would bene-



*Cardiac evaluation by means of bicycle ergometry
Photo by Norman Wexler*



Measuring the extent of extension of the trunk
Photo by Norman Wexler

fit if debriefing sessions after a chase or a shoot-out were designed to lower the level of stress response before they return to duty or go home. The executive requires greater insight into his own drives so that he can cope with the concomitants of stress, and the mortality and morbidity that result from diseased coronary vessels can thus be lowered.

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The County of Los Angeles occupational health service was established in October 1968 to speed processing of applicants for employment and serve county employees, who now number 78,000. To identify cardiac disease in job applicants and current safety workers (law enforcement personnel, deputy marshals, firefighters, lifeguards, and investigators in the district attorney's office), a two-phase examination was established.

Phase 1 consists of a com-

plete medical examination, resting cardiography, and hematologic and blood chemistry studies. The second phase is measuring response to exercise testing (dynamic cardiography), doing pulmonary function studies, and measuring percentage of body fat, spine mobility, and hip, back, and grip strength.

In 17 months, more than 1,800 persons, including a small number of top executives, have been exercise tested. Fifty-two firemen of 529 tested had abnormal findings

on resting or dynamic electrocardiography, and 37 were subsequently placed on sick leave. Twenty-five persons in other departments were identified as having coronary heart disease. Five firemen and one executive have since had bypass surgery using saphenous vein grafts.

To help prevent coronary artery disease in employees, the service has undertaken programs in physical fitness, smoking withdrawal, and individual and group counseling in nutrition.